

95-702 Distributed Systems

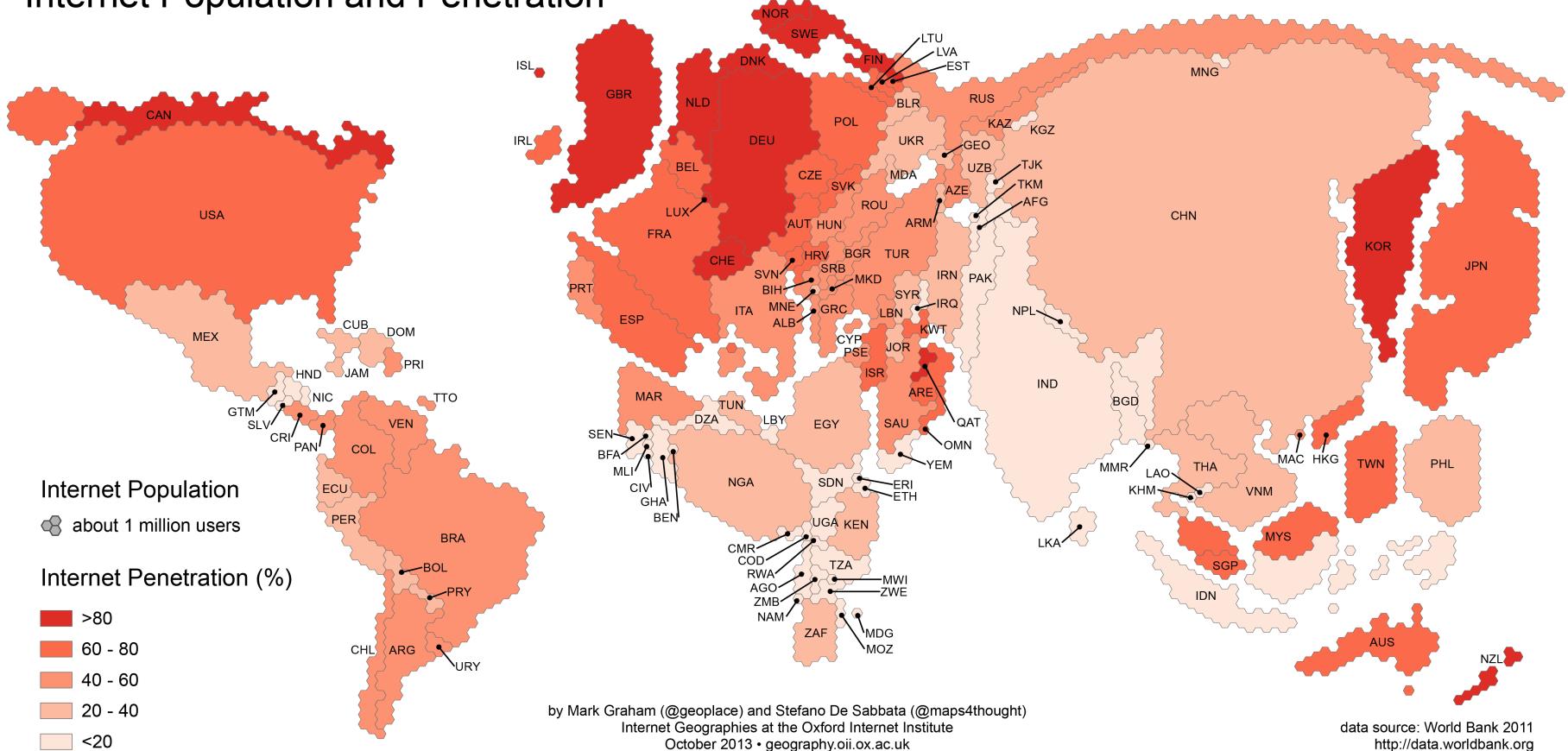
Mobile and Ubiquitous Computing

Stats....

- The following are International Telecommunications Union (ITU) statistics, through 2011, with estimates to last year.
- Source:
<http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013.pdf>
- An interesting way to explore data per country:
 - <http://www.itu.int/net4/itu-d/icteye/>

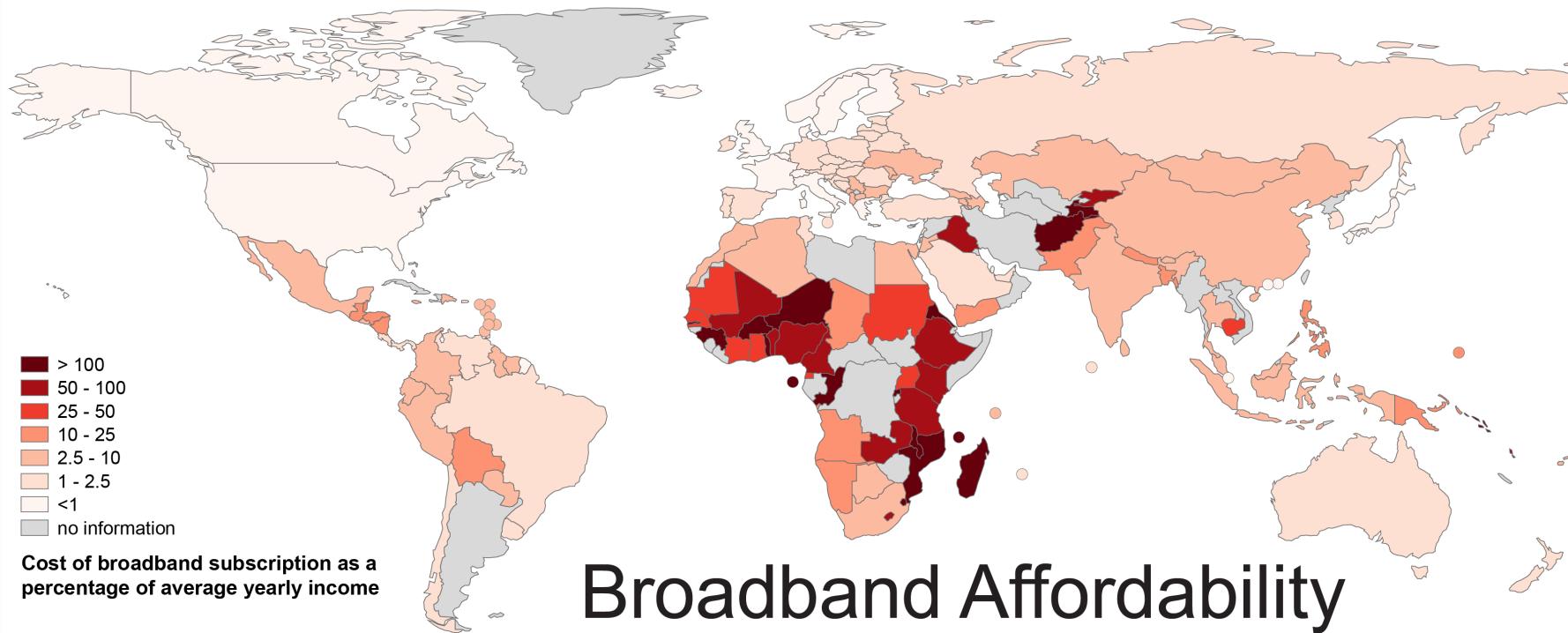
Internet population and penetration

Internet Population and Penetration

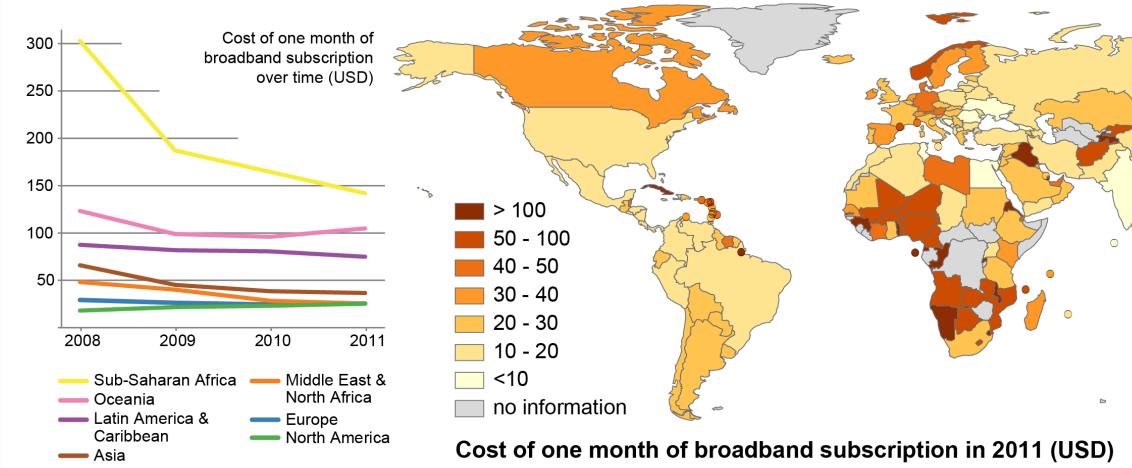


Source: <http://geography.oi.ox.ac.uk/>

Fixed Broadband Affordability



Broadband Affordability

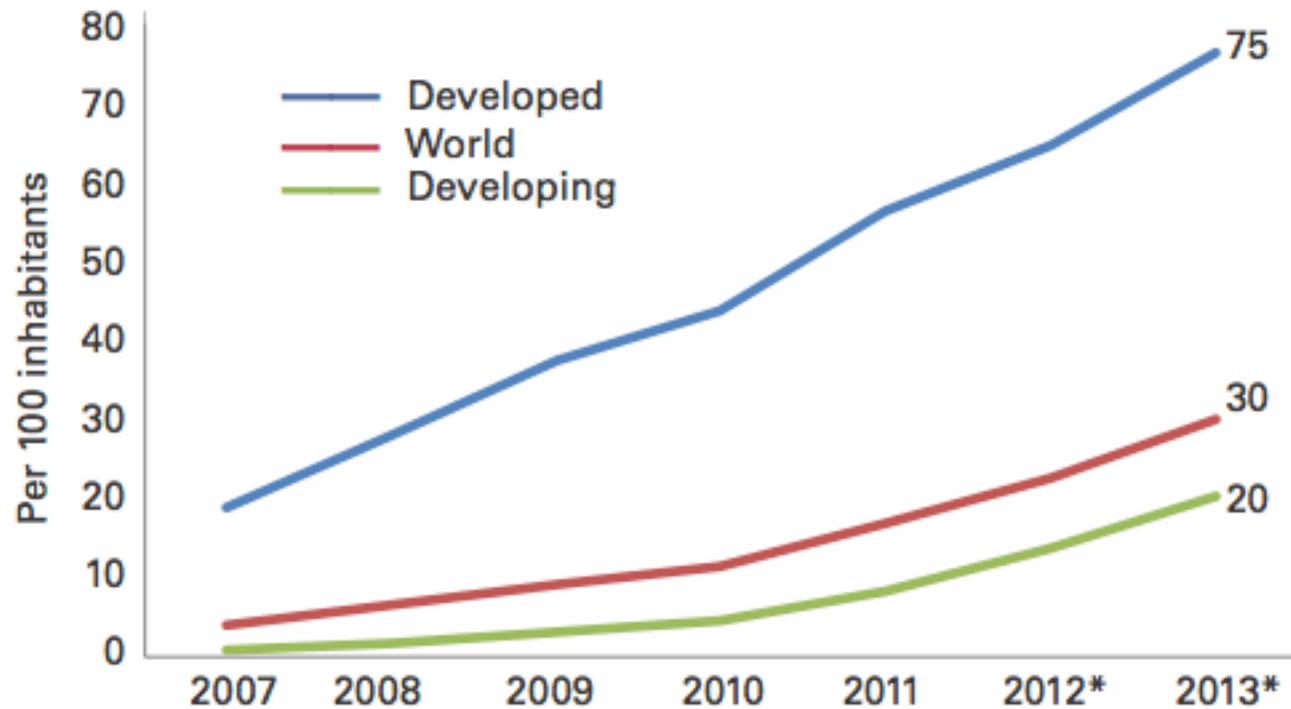


by Mark Graham
(@geoplace)
and Stefano De Sabbata
(@maps4thought)
Internet Geographies at
the Oxford Internet Institute
2014
geography.oi.ox.ac.uk

data sources:
ITU • itu.int
World Bank • data.worldbank.org

Source: <http://geography.oi.ox.ac.uk/>

Mobile broadband subscriptions per 100

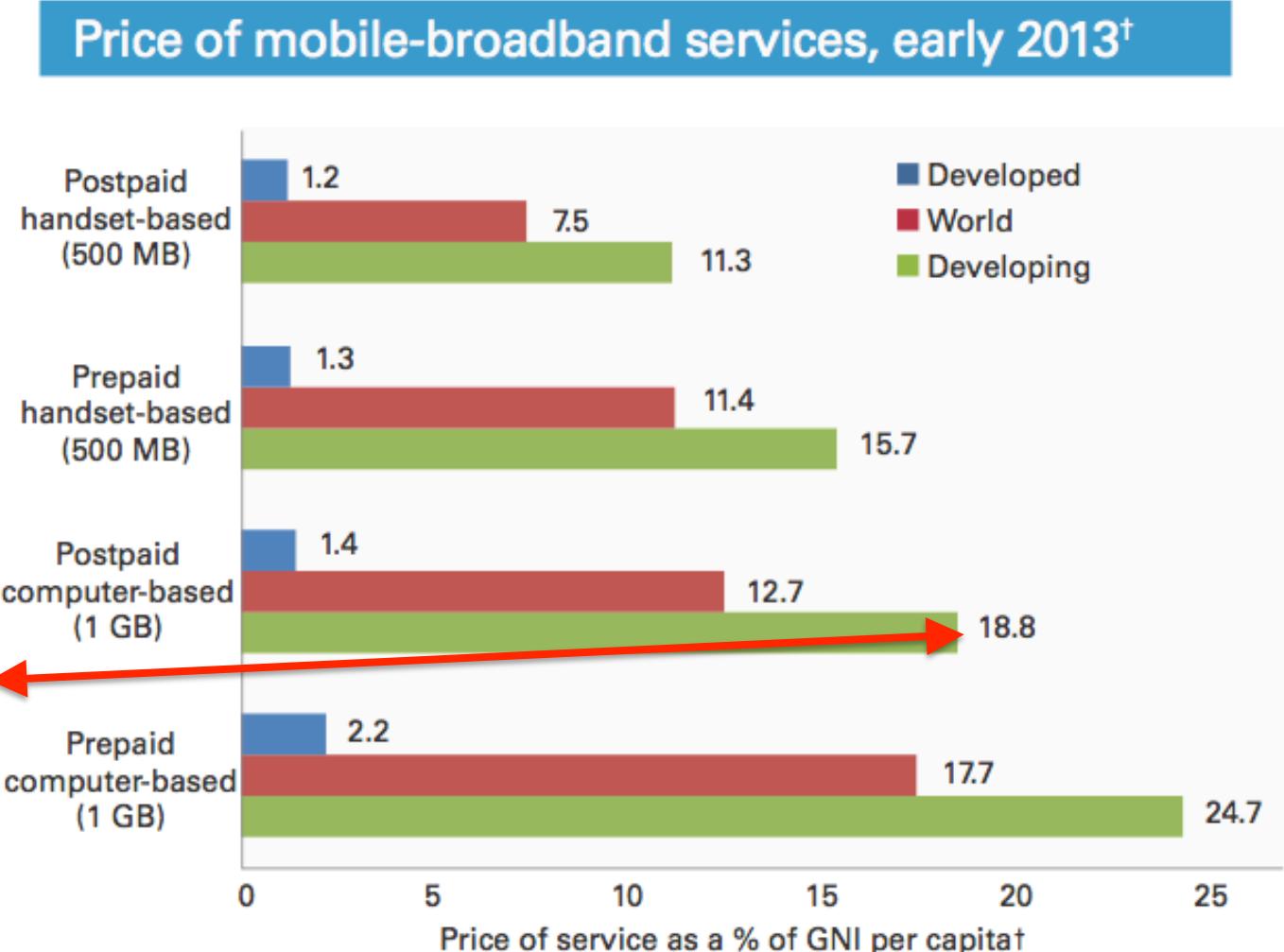


Source: ITU World Telecommunication /ICT Indicators database

Note: * Estimate

Mobile broadband as % GNI per capita

In developing countries, mobile broadband is much cheaper than fixed.



Source: ITU World Telecommunication /ICT Indicators database

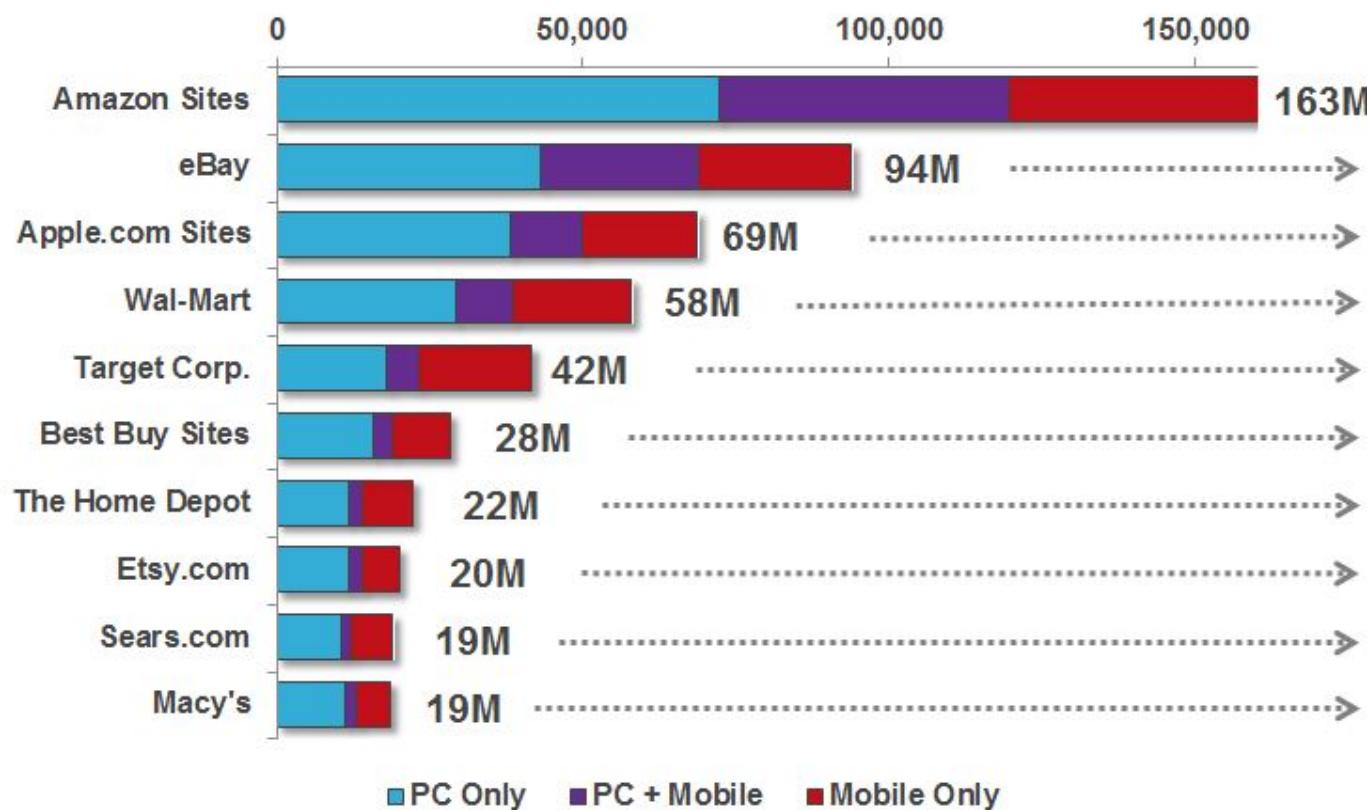
Note: Simple averages. † Preliminary result

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How do users access leading businesses?

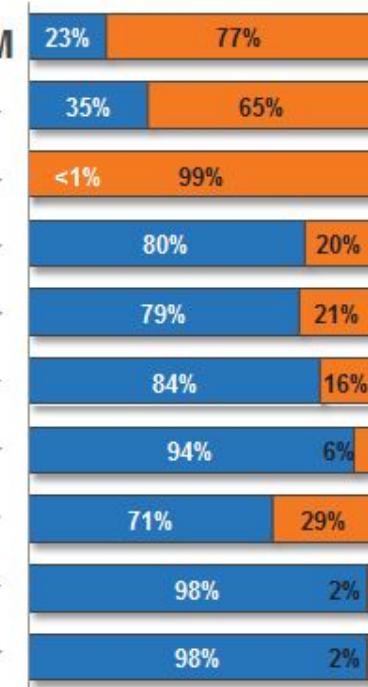
**Selected Leading Retailers: Total U.S. Digital Population
Unique Visitors (000) by Platform**

Source: comScore Media Metrix Multi-Platform, U.S., September 2013



**% of Time Spent –
Browser vs. App**

Source: comScore Mobile Metrix, U.S., Sep-2013



Source: <http://www.comscoredatamine.com/2013/12/amazon-ebay-drive-heavy-app-usage-while-multi-channel-retailers-rely-on-mobile-web/>

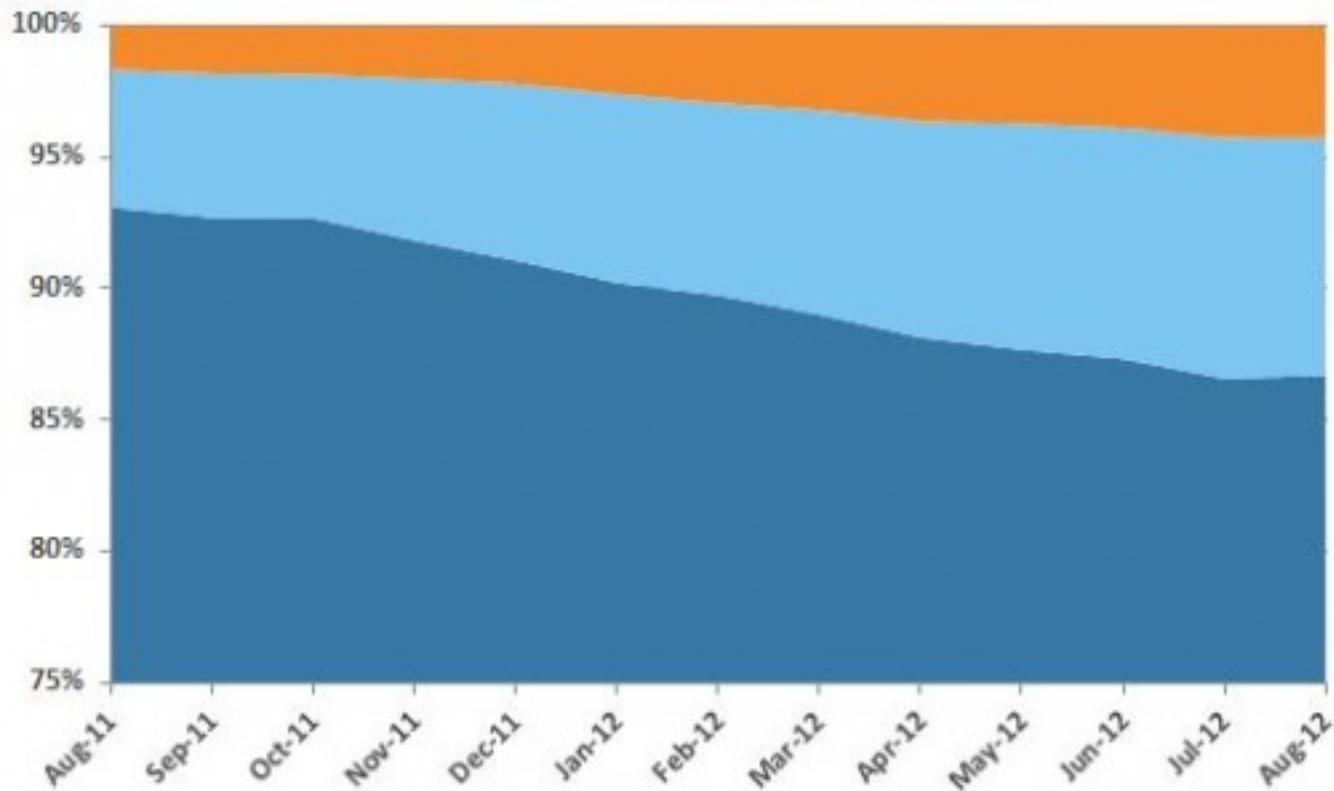
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Change of device use

U.S. Share of Internet Page Views* Across Devices

Source: comScore Device Essentials, U.S., Aug. 2011 - Aug. 2012

■ PC ■ Mobile ■ Tablet

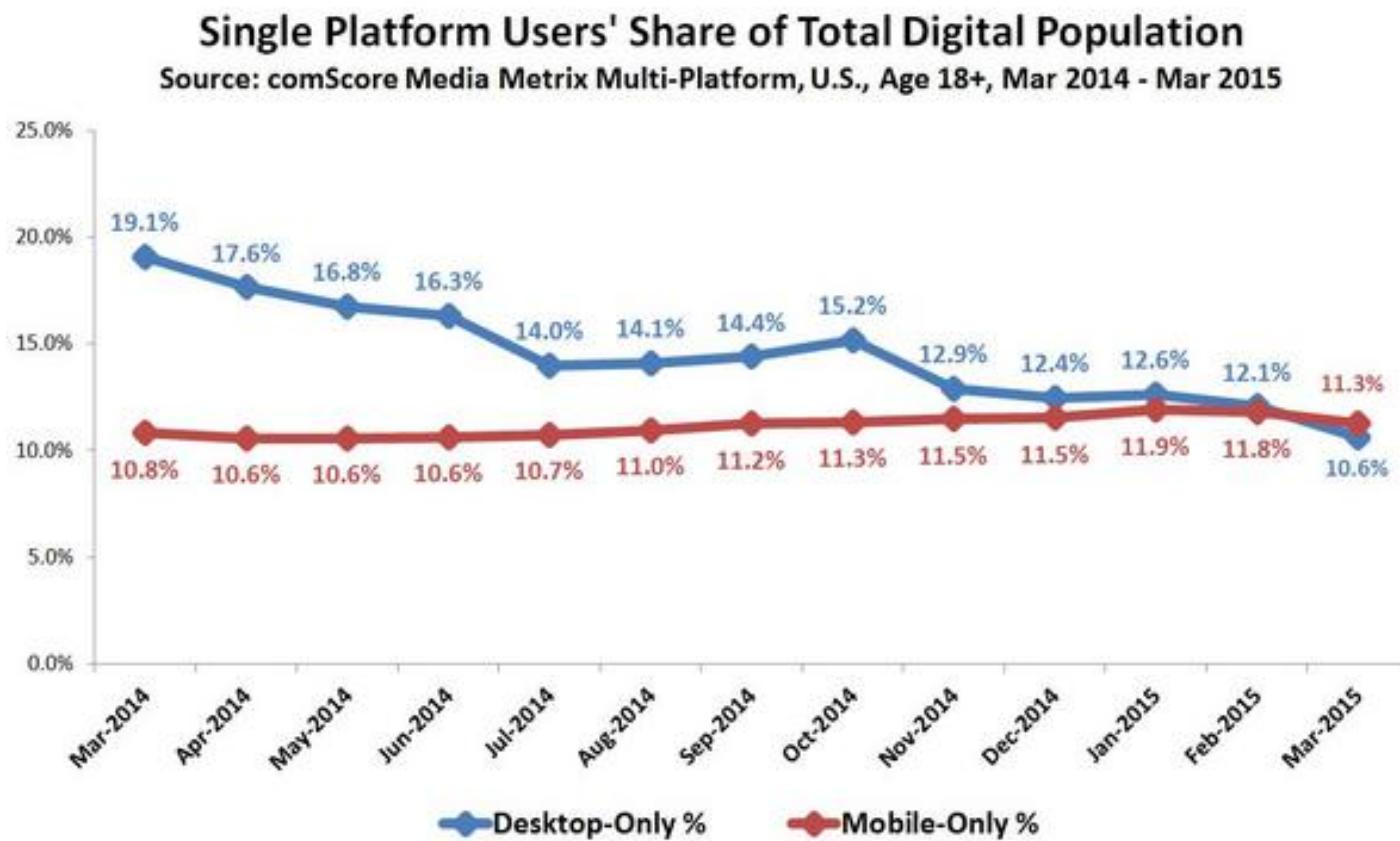


*Excludes apps

Source:<http://www.comscoredatamine.com/2012/10/mobile-phones-and-tablets-now-account-for-1-in-8-u-s-internet-page-views/>

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US Mobile-Only Internet Uses > Desktop



Source: <http://www.comscore.com/Insights/Blog/Number-of-Mobile-Only-Internet-Users-Now-Exceeds-Desktop-Only-in-the-U.S>

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Bottom Line

- In the foreseeable future, mobile devices will be the most prevalent way that people access the Internet, and therefore, distributed systems.

System Design Issues

System Design Issues in Distributed Mobile Applications

- Association
- Sensing and Context Awareness
- Security and Privacy
- Adaptation

Association

- Devices
 - Appear and disappear from the *space*.
 - Do so unpredictably
 - May be totally new to the *space*.
 - Or may be returning to the *space*.
- They need to be:
 - Perhaps added to the network
 - Brought into Association with resources and applications
- Examples of Association
 - Come on campus and be able to be associated with the printers that are close to you.
 - Be alerted if someone you know is walking near you.
 - Be provided with selling prices in your local area for your goods (not prices in far-away areas).

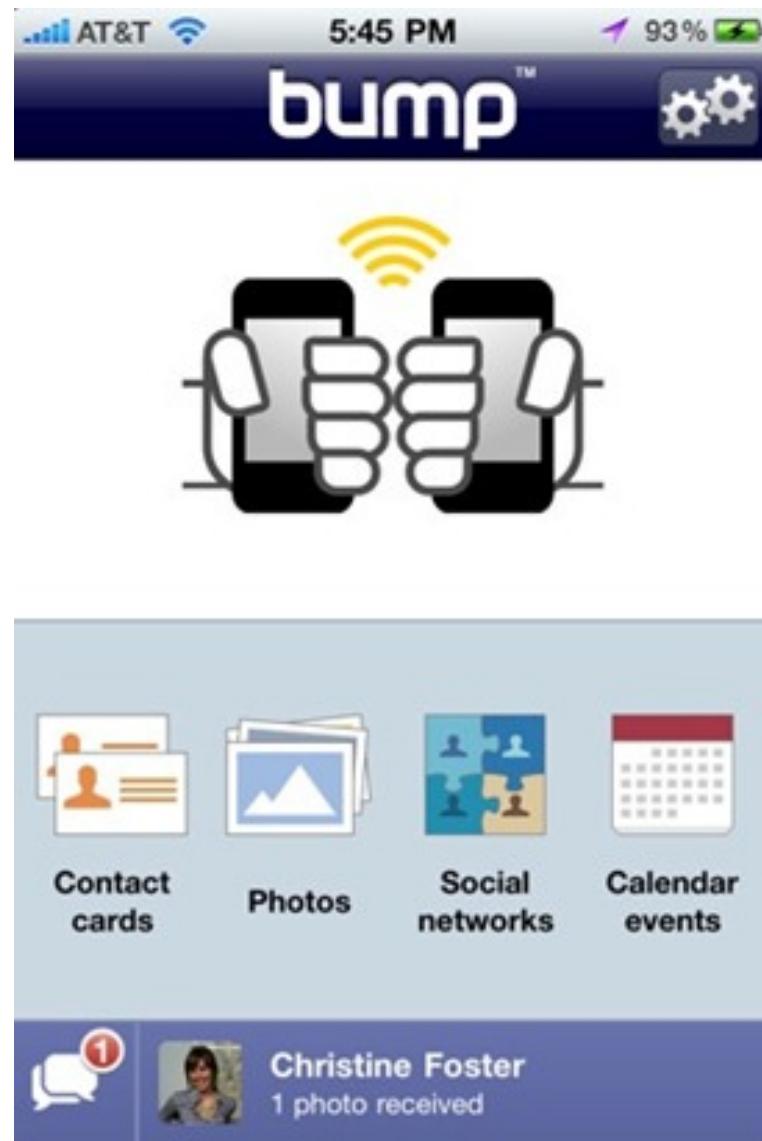
Network-level association

- How does a new device become part of the local network?
- We discuss this in the Networking classes
 - ARP: discovers addressing at the data link layer
 - DHCP provides:
 - A local IP address
 - The local subnet mask
 - IP address of default gateway
 - IP address of DNS server(s)

Application-level Association

- Often managed by *discovery*: *device discovery and/or service discovery*.
- Devices and/or services can register with a directory services
 - New clients can search the directory
- Devices and/or services can reply to broadcasts of requests
 - E.g. Bluetooth, when in *discover* mode, broadcasts the device, and its services.

Bump's Interesting Association Model



Association within Bump

Quoted from Bump FAQ: <http://bu.mp/faq>

Q: How does Bump work?

A: There are two parts to Bump: the app running on your device and a smart matching algorithm running on our servers in the cloud. The app on your phone uses the phone's sensors to literally "feel" the bump, and it sends that info up to the cloud. The matching algorithm listens to the bumps from phones around the world and pairs up phones that felt the same bump. Then we just route information between the two phones in each pair.

Q: No way. What if somebody else bumps at the same time?

A: Way. We use various techniques to limit the pool of potential matches, including location information and characteristics of the bump event. If you are bumping in a particularly dense area (ex, at a conference), and we cannot resolve a unique match after a single bump, we'll just ask you to bump again.

Association Models

- WeChat "shake"
- Other interesting ones?
- The most common association is membership
 - Sign-up
 - Identify "friends"

Issues in developing Mobile systems

- Association
- Sensing and Context Awareness
- Security and Privacy
- Adaptation

Sensing and Context Awareness

- Sensing:
 - Camera
 - Time
 - Acceleration
 - Location
 - Speed
 - Temperature, moisture, blood sugar, light levels, etc.
- Context awareness
 - In terms of sensed data
 - Also in terms of associated data
 - E.g. If the user is Fred and he is in the TOP SECRET meeting room and there is a display within 1 meter of him and no non-top-secret person nearby, then show information on the display.

Location Sensing

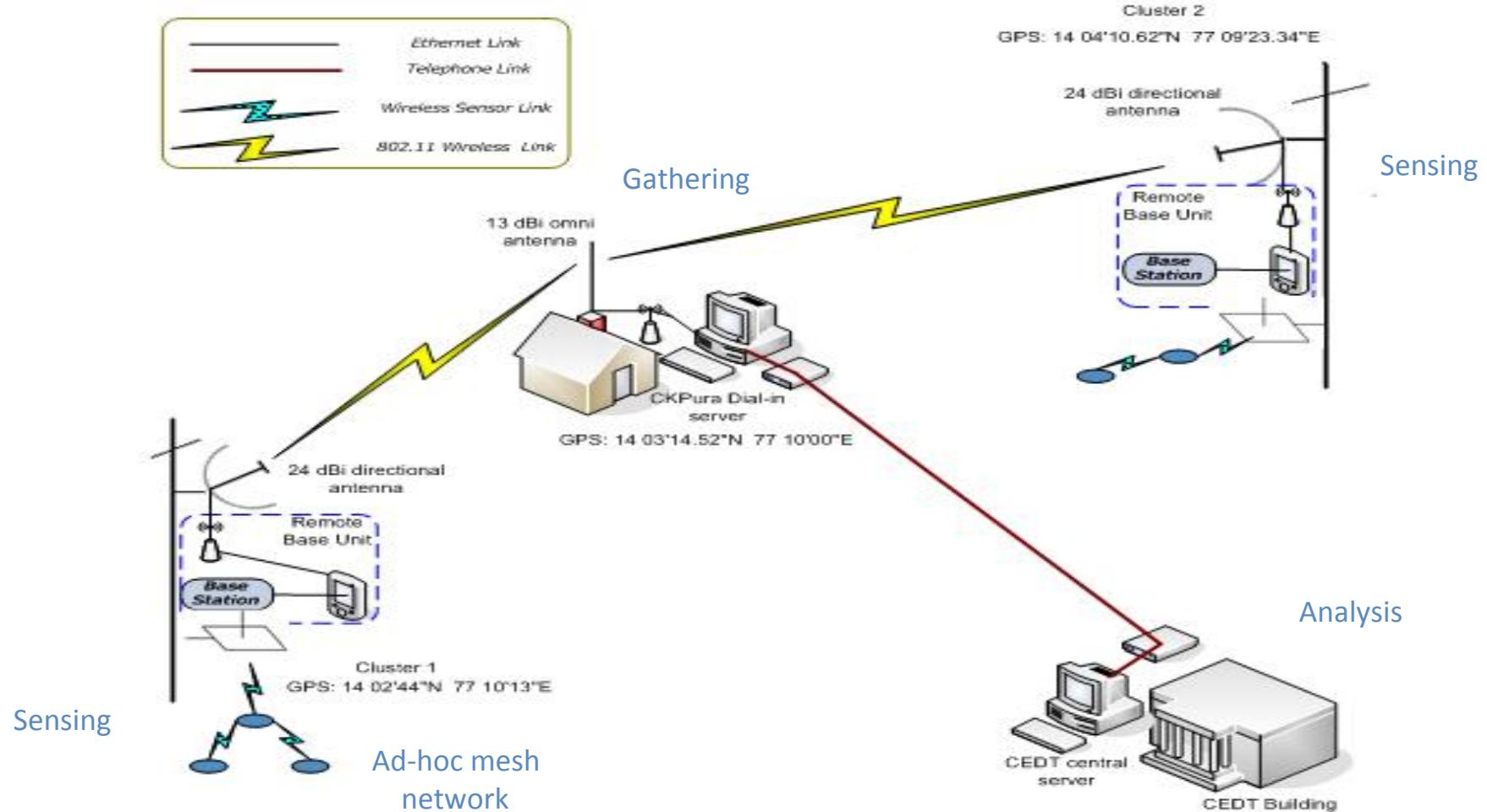
- GPS
- Database of collected Wifi access points
 - stores the access point's MAC address and the GPS location at which it was observed
- Cellular – compute using signal strength to multiple cellular tower locations
- RFID tags – tags are associated with a location

Sensor Networks

- Sensor networks are collections of small distributed computing systems with sensors that are used to monitor the environment, homes, and businesses.

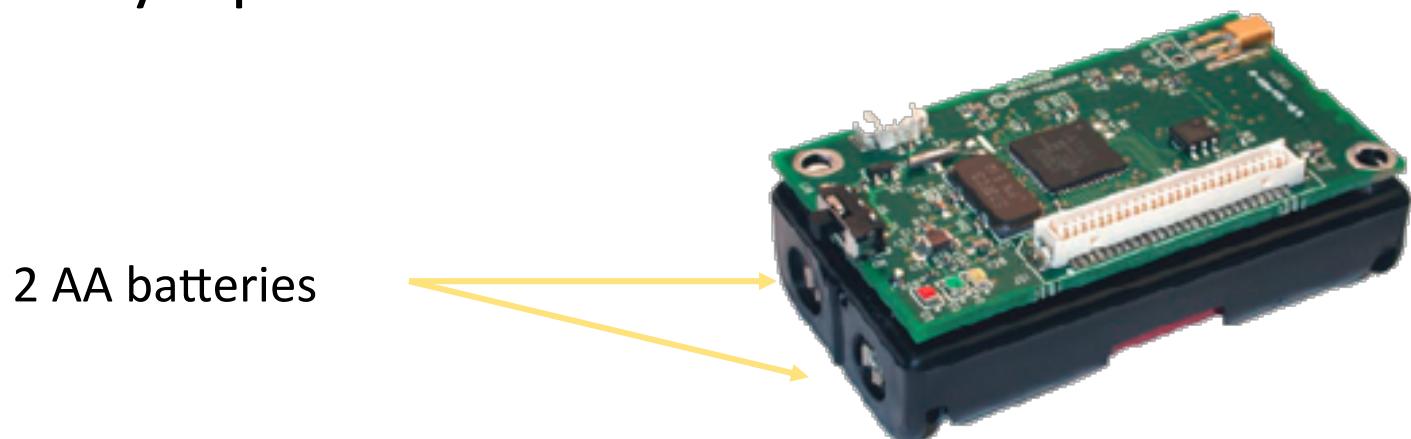
Agricultural Monitoring

Common Sense-Net



Common-Sense Net

- Meteorological and Soil Sensors
- Connected to a mote
 - A specialized teeny computer
 - With 802.11 connectivity,
 - Powered by a pair of alkaline batteries



Wireless Sensor Network (WSN) Examples

- Monitoring home power usage
 - <http://dl.acm.org/citation.cfm?doid=1460412.1460449>
 - Nest Learning Thermostat: <http://www.nest.com>
- Safety Assurance for Archeologists
 - The location of archeologist team members are monitored to make sure all are safe and none get lost.
 - dl.acm.org/citation.cfm?id=1460451
- Medical Emergency Detection
 - "MEDiSN, a wireless sensor network for monitoring patients' vital signs in hospitals and disaster events."
 - <http://dl.acm.org/citation.cfm?id=1460452>
- Electrical Power Grid Monitoring
 - A "wireless sensor network that is deployed in a substation for monitoring the health of power subsystems such as circuit breakers, trans-formers and transformer bushings."
 - <http://dl.acm.org/citation.cfm?id=1460454>
- Tracking the debris flow of land slides
 - dl.acm.org/citation.cfm?id=1460412.1460476
- Determining the shelf-life of fruits and pharmaceuticals by monitoring their environmental conditions while in transit
 - "wireless sensor nodes called SmartPoints monitor the environmental conditions and generate alarms when specific events are detected. Additionally, they calculate the remaining shelf life of the perishable goods they travel with. When there is an Internet-connected WSN available during travel, the shelf-life prediction and associated alarms are directly sent to a back-end server. "
 - <http://dl.acm.org/citation.cfm?id=2070965>

Internet of Things

- Sensors
 - e.g. light, IR, pulse
- and actuators
 - e.g. motors, solenoids, relays
- with the ability to communicate wired or wirelessly
 - e.g. wifi, bluetooth
- using standard Internet protocols
 - e.g. IP, TCP, UDP
- embedded into physical objects
 - e.g. thermostats, traffic lights, cat collars, doorbells
- to provide enhanced capabilities
 - e.g. intelligent control, convenience, security

Tile

- Association
 - Bluetooth
 - Registered to a user
- Sensing / Context
 - iOS app will show strength of signal from tile
 - tile has speaker
 - (If lost) when another user runs across the tile, it will anonymously update the tile's location
 - assumedly using the phone's GPS
- Cloud computing:
 - SaaS
 - Crowdsourcing (HuaaS)

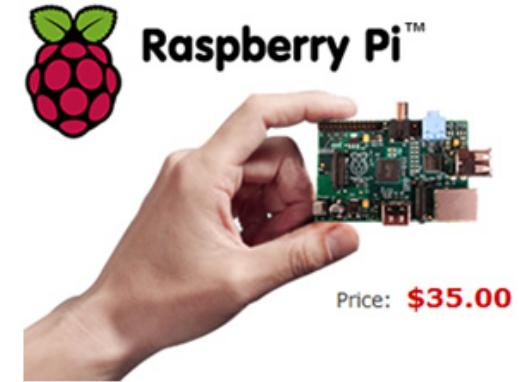


Other examples

- Nest thermostat
- Philips Hue lighting
- Others you have used?

Raspberry Pi

- \$35 computer
- Linux
- Fixed or wifi networking
- I/O Pins
- Can run a Java Web Container
 - Tomcat
 - Glassfish
 - Jetty



Issues in developing Mobile systems

- Association
- Sensing and Context Awareness
- Security and Privacy
- Adaptation

Security and Privacy

- Who is allowed to associate?
- Once associated, what resources or services can I use?
- Once associated, who else will know that I'm there, and what can they learn from me?

Sensing and privacy

- Be careful about what you are sensing...
- “Google has admitted that its Street View cars had ‘accidentally’ collected data from unsecured wi-fi networks in more than 30 countries.”
 - <http://www.bbc.co.uk/news/technology-11000854>
- Apple had a "bug" (since fixed) that tracked your location data and stored it on your phone and synced computer.

Tile?

- Can you track a person by slipping a Tile onto them?
 - Their car?
 - Inner fold of their backpack/luggage?

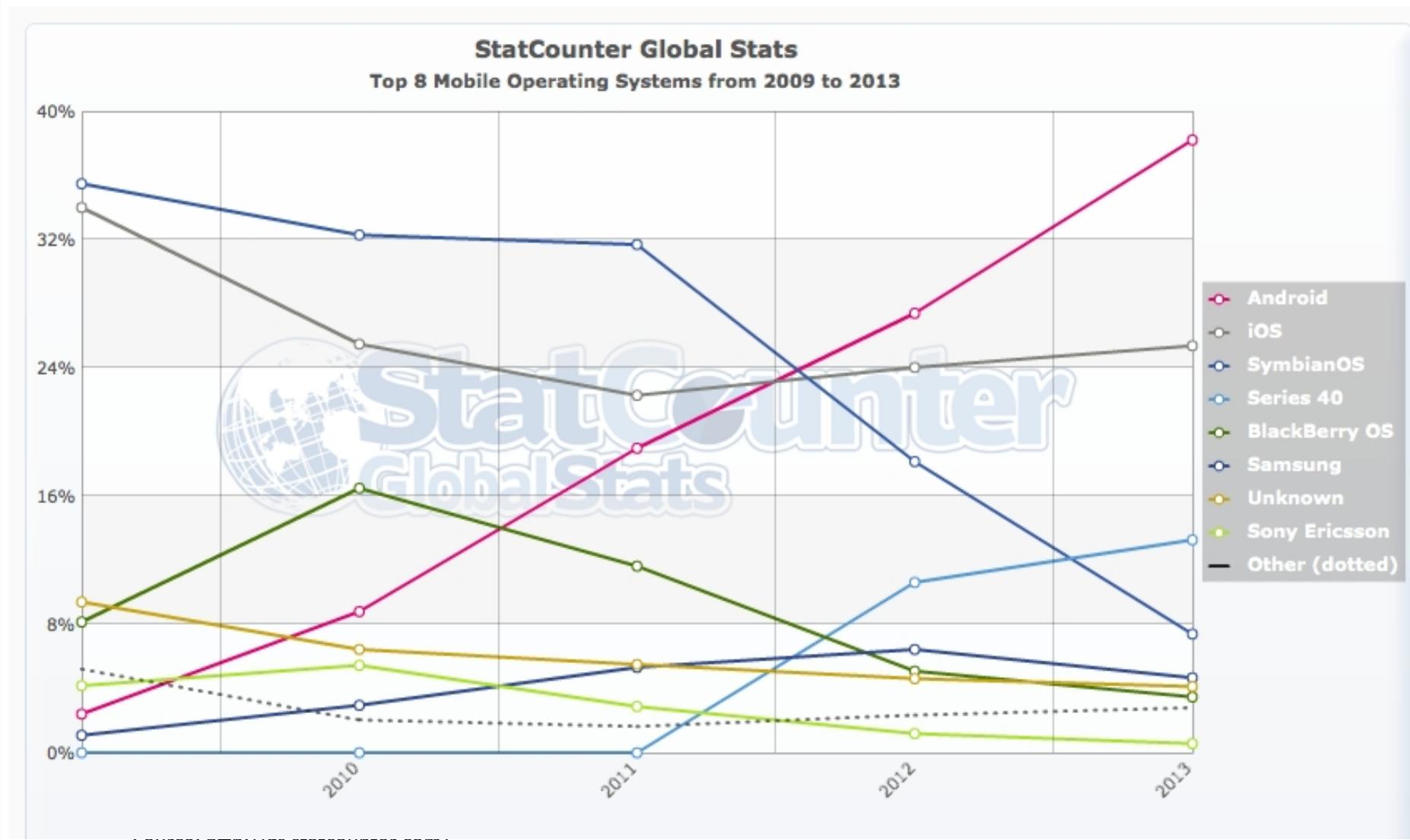
Issues in developing Mobile systems

- Association
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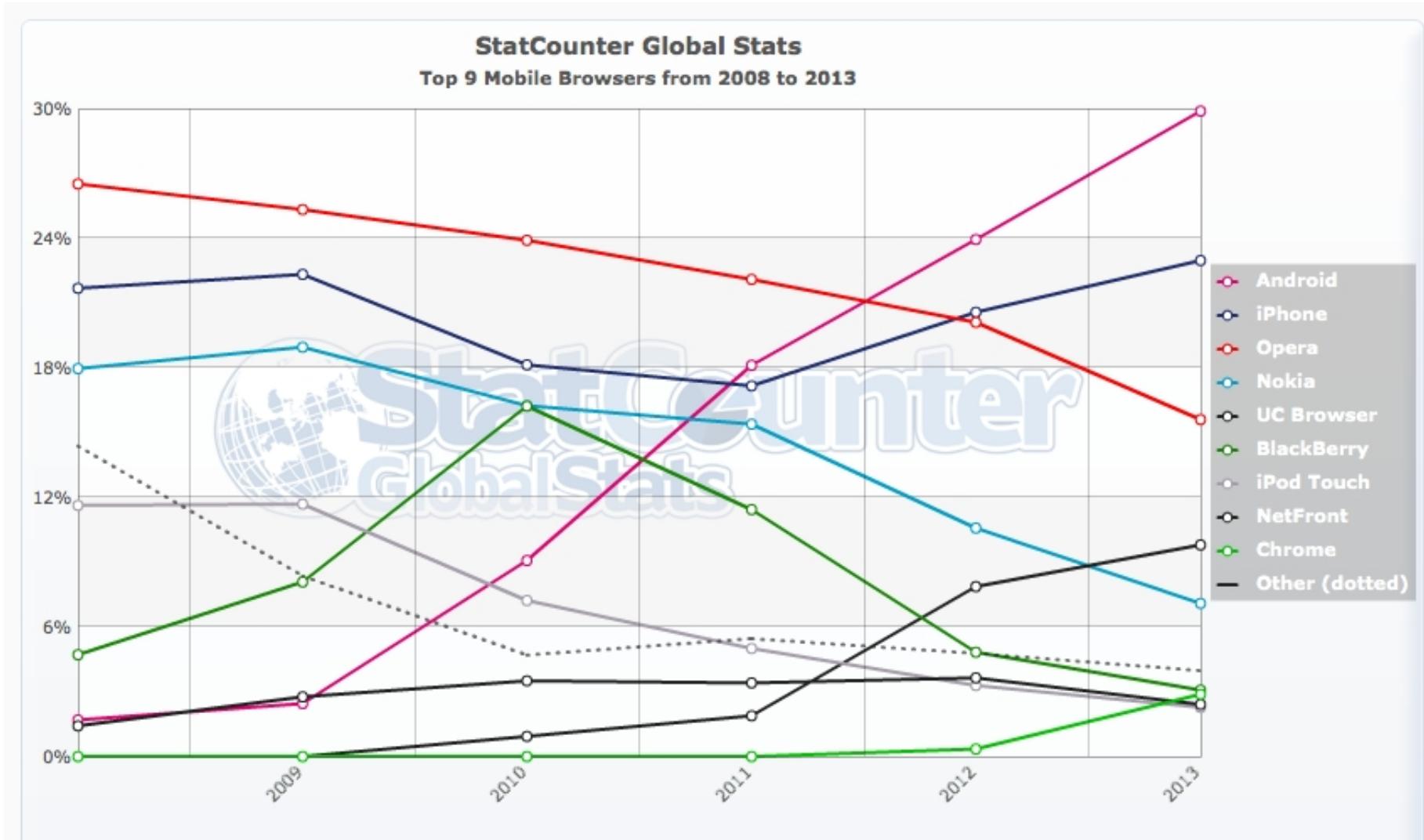
Adaptation

- Adapt application based on the resources of the device, and its context.
- Adapt
 - Presentation to fit the screen
 - Use of JavaScript to fit the devices capabilities
 - Media quality to fit the screen and device capabilities
 - Language to fit the user
 - Information to fit the physical context.
 - Give only movie times in the future, and in nearby theaters

Global Mobile OS Market Share

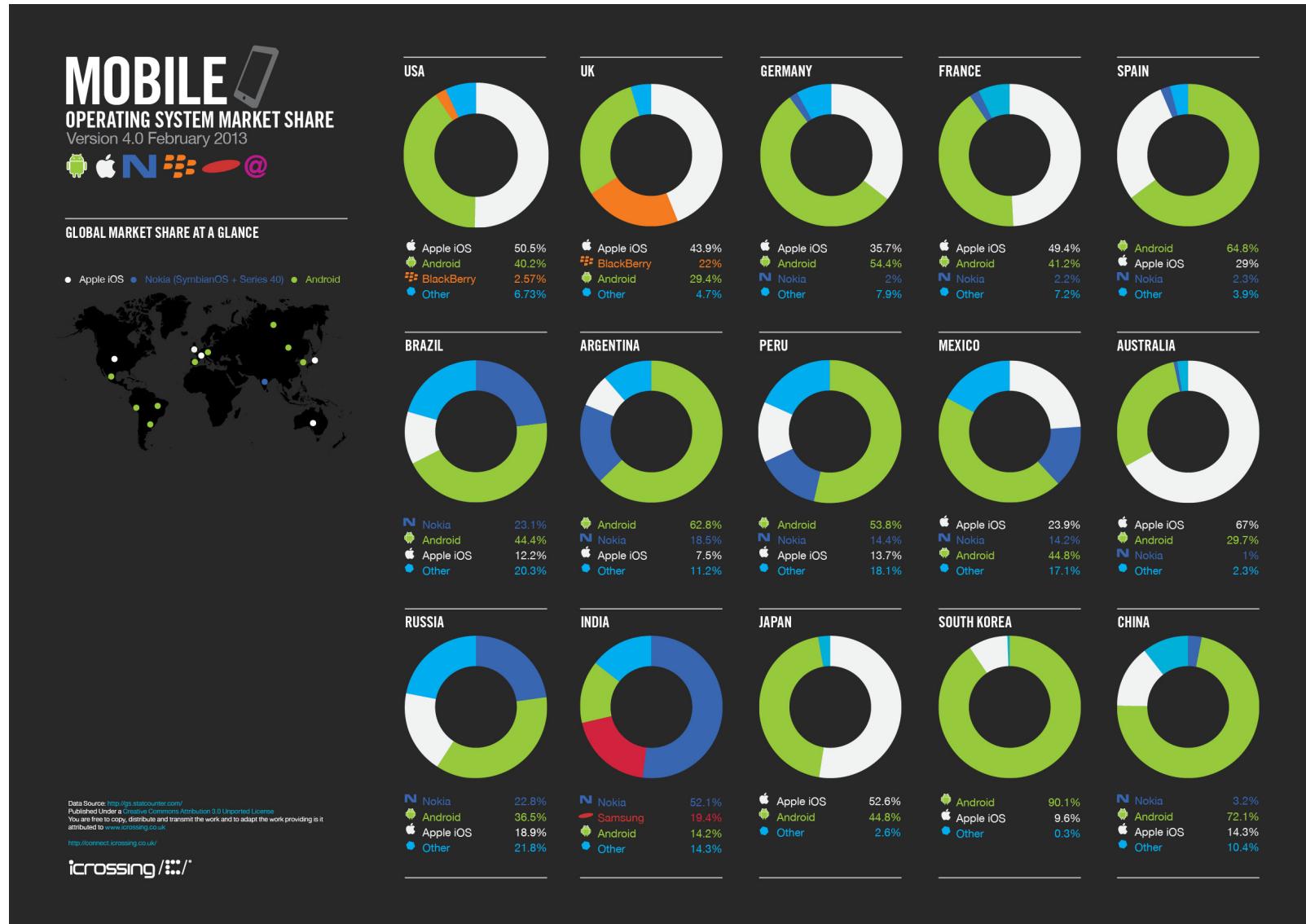


Global Mobile Browser Market Share



Source: <http://gs.statcounter.com/>

Varies by Country



Source: http://connect.icrossing.co.uk/wp-content/uploads/2013/01/iCrossing_2013_Mobile_Market_Share.gif

Data from StatCounter

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How is Mobile Web Different Than Desktop?

- Smaller bandwidth
- More frequently users are paying by the MB/GB
- Smaller display
- Touch vs mouse
 - Or no pointing device at all on older feature phones
- Less computing power
- Making more use of computing and communication depletes batteries faster.
- Less browser memory
- Less cache space
- Limited keyboard
- Small keyboard keys

Mobile Markup History

- WML – Wireless Markup Language
 - Older, simpler markup language for low-power devices.
 - Dialect of XML
 - For monochrome devices with low memory and power.

Other Old Markup Languages

- CHTML
 - Compact HTML
 - On Japanese DoCoMo mobile network
- XHTML Basic
 - Around 2000 by W3C
 - Simpler than HTML
 - Preceded XHTML-MP

Mobile Markup Today

- HTML, XHTML, a lot of HTML5
 - On many smart phones
 - Same as on desktops
 - Also CSS3 (the latest desktop styling standard)
- But be aware of your market. Smartphones can be very rare in some markets.

Device Awareness

- How do we know what type of device is making request?
- 3 HTTP headers provide clues:
 1. User-Agent
 - Identifies the mobile browser and almost always the device manufacturer and model.
 - BlackBerry8330/4.3.0 Profile/MIDP-2.0 Configuration/CLDC-1.1 VendorID/105
 - Collection of mobile agent strings:
 - http://www.zytrax.com/tech/web/mobile_ids.html
 2. X-Wap-Profile
 - Link to an XML profile of the phone's capabilities
 - E.g.
<http://www.blackberry.net/go/mobile/profiles/uaprof/8310/4.2.2.rdf>
 3. Accept
 - Supported MIME types
 - E.g. text/html, application/xhtml+xml, etc.

Device Awareness

- These 3 headers should provide enough info
- BUT
 - Headers can be missing
 - Have inaccurate values
 - Have invalid URLs
- Device capabilities databases exist
 - E.g. Wireless Universal Resource File (WURFL)

WURFL E.g. Samsung SGH T139

- Fairly cheap phone (\$20, no contract)
- [http://www.tera-wurfl.com/explore/?
action=wurfl_id&id=samsung_sgh_t139_ver1](http://www.tera-wurfl.com/explore/?action=wurfl_id&id=samsung_sgh_t139_ver1)
- 220x176 Display
- Full HTML4
- Full Ajax support



© 2010 CBS Interactive

Server-side Content Adaptation

- Therefore we can query the WURFL database
 - Base our response on device capabilities
- But there are no fixed set of sizes
 - Small (e.g. iPhone 4s) to TV.

Feature detection

- A much more flexible and reliable solution is to use *feature detection*.
 - Don't try (or trust) basing decisions globally on the capabilities of a browser
 - Rather, each time a feature cannot be universally assumed, test for it before using it.
- Richard Cornford and Garrett Smith give a very good discussion of device vs feature detection:
 - <http://jibbering.com/faq/notes/detect-browser/>
- Bottom line:
 - **Use feature detection, not browser detection.**

Two strategies for Feature Detection

- Graceful degradation
 - Design for modern browsers
 - Where features are not available, provide a simpler alternative
 - If not possible, alert the user
 - Don't allow it to invisibly fail
- Progressive enhancement
 - Design with a baseline of usable functionality
 - Enrich the user experience step-by-step by testing for features before using them.

Progressive Enhancement Example



Source: <http://dev.opera.com/articles/view/progressive-enhancement-with-css-3-a-be/>

Example: "Print this invoice"

- Updated browser:

```
<p id="printthis">  
<a href="javascript:window.print()">Print this page</a>  
</p>
```

- Graceful degradation

```
<p id="printthis">  
<a href="javascript:window.print()">Print this page</a>  
</p>  
<noscript>  
  <p class="scriptwarning">  
    Printing the page requires JavaScript to be enabled  
    Please turn it on in your browser.  
  </p>  
</noscript>
```

Source: http://www.w3.org/community/webed/wiki/Graceful_degradation_vs_progressive_enhancement

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This example assumes that users:

- Know what JavaScript is
- Know how to enable it
- Have the rights and the option to enable it
- Are OK with turning on JavaScript just to print a document

Source: http://www.w3.org/community/webed/wiki/Graceful_degredation_versus_progressive_enhancement

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Example "Print this invoice"

- Progressive enhancement starts with:

```
<p id="printthis"> Thank you for your order.  
Please print this page for your records.</p>
```

- And then enhances with:

```
<script type="text/javascript">  
(function(){  
    if(document.getElementById){  
        var pt = document.getElementById('printthis');  
        if(pt && typeof window.print === 'function'){  
            var but = document.createElement('input');  
            but.setAttribute('type','button');  
            but.setAttribute('value','Print this now');  
            but.onclick = function(){  
                window.print();  
            };  
            pt.appendChild(but);  
        }  
    }  
})();  
</script>
```

Source: http://www.w3.org/community/webed/wiki/Graceful_degradation_vs_progressive_enhancement

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Progressive Enhancement

- This does not assume anything, but tests first
 - Tests for browser support of JavaScript
 - Tests if the element exists
 - Tests if the window object has a print method
- Only if all these are true does it
 - Create a "Print this now" button
 - Add it to the page
- This code will work for every user regardless of:
 - The version of browser they are using
 - Whether or not they have JavaScript enabled
- The "promise" suggested by the user interface (i.e. printing) is only displayed when it is known to be available.

Responsive Web Design

- A strategy of web design for multiple screen sizes
- Uses:
 - Fluid grids expressing sizes in terms of percents, not pixels
 - Modify size of media using relative units
 - Keep them within their bounding elements
 - Images
 - Media
 - Font size
 - Crossing size thresholds switch to completely different designs
 - Accomplished using media queries

Responsive Web Design

- Coined by Ethan Marcotte
 - Visit: <http://alistapart.com/article/responsive-web-design>
 - Also published a book: *Responsive Web Design*
- Notice in his examples:
 - Fluid design using relative sizes
 - Media size changing
 - Crossing size threshold alters type of navigation

Mobile First

- A philosophy of web design
- Design for mobile first, and desktop second
- Counter to what has been done historically, of mobile 2nd
- Benefits of Mobile First:
 - Focus on the platform on which you will reach the most users
 - Forces designers to focus on the most important content and functionality
 - Allows for using technologies on mobile:
 - touch events
 - geolocation
 - accelerometer
- Articulated by Luke Wroblewski
 - Video: <http://www.lukew.com/presos/preso.asp?26>

Summary of current design practices

- Progressive Enhancement

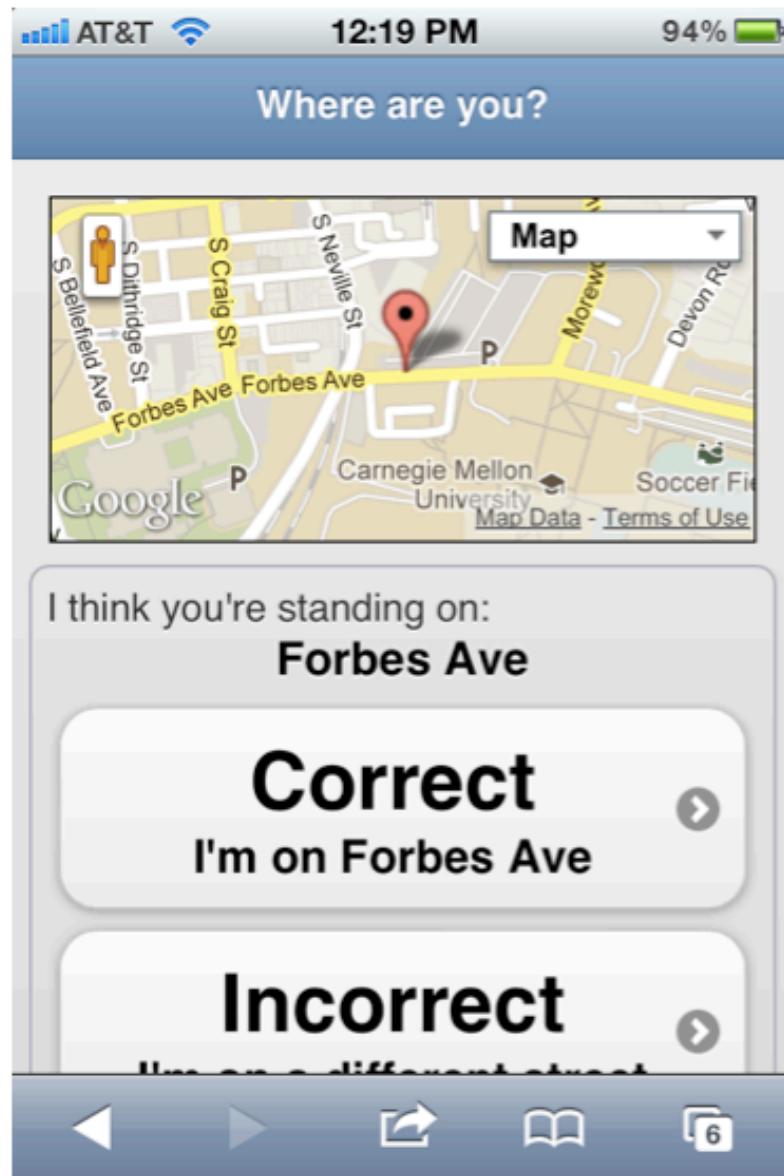
Via:

- Responsive Design
- Mobile First
- Frameworks exist to help implement this approach
- E.g.
 - jQuery Mobile
 - Twitter Bootstrap 3

jQuery Mobile

- Supports a unified UI framework
- Across all popular mobile device platforms
 - phones and tablets
- Built on jQuery (a desktop UI framework)
- Themeable design
- Supports touch events
- Accessibility for assistive technologies
- Embodies ***progressive enhancement!***
- <http://jquerymobile.com/>

MISM Capstone: Disaster Assessment App



The screenshot shows a web browser window titled "Detailed Interview" with the URL 128.2.82.244:8080/Capsto... The page contains a series of questions and input fields. The first question is "Number of floors:" with a value of "2" and increment/decrement buttons. The next two questions are "Is there a basement?" and "Is the basement occupied?", each with "Yes" and "No" buttons, where "Yes" is selected. The next section asks "Please describe the way in which the basement is being used:" with the response "for storage". Subsequent questions ask about water levels: "How much water is in the living area?" (12 inches) and "How much water is in the basement?" (12 inches). Finally, there are two more questions: "Is the electricity on?" and "Is the gas on?", each with "Yes" and "No" buttons.

Twitter Bootstrap 3

- Also implements support for:
 - Progressive Enhancement
 - A Mobile First strategy
 - Responsive Design
- You can see docs / demo at:
 - <http://getbootstrap.com/css/>

Mobile Deployment Options

- Native
 - E.g. Android, iOS
 - Requires redeveloping for each architecture
 - 2 code bases
- Native with Development Framework
 - Use a framework that compiles to multiple native applications
 - E.g. Corona (<http://www.coronalabs.com>)
 - Develop code in Lua

Mobile Deployment Options

- Mobile Web
 - Develop in HTML / CSS /JavaScript
 - Accessed in a browser
 - Can install local icon to launch to site
 - Use local storage to store information when off line
 - Use manifest to cache application to use when off line
 - Sync when Internet is again available.
- Hybrid
 - Develop in HTML / CSS / JavaScript
 - Wrap in a browser wrapper to create native apps
 - Wrapper provides access to phone hardware not accessible from the browser
 - Phonegap (<http://phonegap.com>) is a generally-available native wrapper

Recap: Issues in Mobile Systems

- Association
 - Discovering and linking to contextual services
- Sensing and Context Awareness
 - Using environmental inputs (e.g. accelerometer, gps)
 - Associative data (e.g. membership)
 - And other data (e.g. time of day, bus schedule)
- Security and Privacy
 - Guarding against:
 - Unauthorized access to information or services
 - Unauthorized modification of information.
 - Disrupting the access to information or services.
- Adaptation
 - Native vs Common Development Framework vs Hybrid apps vs Web apps
 - If Web or Hybrid
 - Use feature detection to determine capabilities of the client device
 - Use Progressive Enhancement based on those capabilities
 - Responsive Web Design (RWD, or Responsive Design)
 - Mobile first